The Sidereal Messenger.

"In the present small treatise I set forth some matters of interest to all observers of natural phenomena to look at and consider."
—GALILEO, *Sidereus Nuncius*, 1610.

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HINTS ON DOUBLE-STAR OBSERVING.

BY S. W. BURNHAM.

It should be stated, at the outset, that the suggestions here made are, in the first place, only intended for amateurs who have had little or no experience in this field of astronomical work, and in the second place, are derived from my own experience solely, and, therefore, entirely independent of, and not always in accordance with, the opinions and methods of some observers. They are given for what they are worth, and, if taken together, they serve to aid beginners, the object sought will be accomplished. It has been often said the observation of double-stars is a work particularly suited to amateurs, but I do not think the statement can be generally accepted, for several reasons among which are: A better quality of instrument is required than for most other purposes, as well as an observatory, driving-clock, micrometer, and other accessories of a first-class instrument, which are not always in reach of the amateur; and much more experience is necessary to make a good observer with the micrometer than is required for meridian work, and in most work with the equatorial. There is, perhaps even now, a greater lack of competent observers in this work than in any other branch of practical astronomy; and it has been so from the first. There are, altogether, not a dozen

first-class observers living who can measure accurately such objects as are regularly observed by Dembowski and Otto Struve. Of course, many can measure with tolerable correctness, easy and wide pairs like Castor, γ Virginis, 61 Cygni, etc., but the time has come when something more is required, and measures will fail to possess that interest and value they would have if the old beaten path were not so steadily followed. The way in which a large part of the work has been done with reference to the selection of objects, is much as it would be in another department of work, if astronomers were to keep on observing the satellites of Jupiter, because they are bright and easy, and neglect all the other members of the solar system. A thorough and undivided interest in the work, and constant practice, will lead to steady progress in the class of objects observed, and in the results. It is true that a very considerable portion of double-star work of all kinds has been done by non-professional observers, but as experts they would rank among the highest, and they have acquired their skill by a long course of training. There is room for many more workers in the field, and with the increasing number of interesting objects, there is no probability of the observations keeping pace with the demands of the work. There is now, and always will be, enough to do for all the instruments even of very moderate size, that can be given to the work; but it is important that it should be well done. Inaccurate observations will be very soon detected when they are compared with a series of measures over a number of years; and will practically be thrown out, as they should be, in discussing the relative motion, or fixity, of the components.

THE TELESCOPE.

Whatever instrument is used as to kind and size, it must be of first rate quality. It is indispensible that the definition should be perfect or as near perfection as can be attained by the best opticians. If wanting in this respect, notwithstanding it may show faint stars well enough, it will be best to discard it, and substitute a more perfect object-glass, of even much smaller aperture if necessary. It may be properly said that for this work a telescope is either very good or good for noth-

ing. After unsuccessfully trying star after star which the observer had good reason for supposing could be seen with his aperture, he is very apt to think his vision though good in every-day use, is in some way deficient for this particular purpose, and is soon discouraged from following up the work. A great deal is charged to the eyes of observers, and to the weather incident to the particular place, which really belongs to the instrument itself.

The instrument must be equatorially mounted, and should have circles of some kind, though they need not be expensive, nor finely graduated. It will answer all purposes if the declination circle is divided to degrees only, as the error in reading or setting the circle by estimation, without a vernier ought not to exceed 10′, and this is near enough to find any object without trouble, and to identify any pair that is picked up. A corresponding graduation of the hour-circle will be sufficient for getting the approximate Right Ascension. It is assumed that the adjustments will be carefully attended to in setting up the instrument. There is not the least necessity for an astronomical clock, or chronometer, or any standard time. For all practical purposes, nothing is so convenient as an ordinary watch, used as a sidereal time-piece for the time being. It can be set in a few moments at the commencement of the night's work from the stars themselves, and is then ready for use when wanted; during the rest of the evening the difference between its rate and that of a clock keeping sideral time being of no practical consequence for the few hours which work would ordinarily be continued. For the purpose of setting the watch, Proctor's "Hand-book of stars," which gives the places for 1880 of all bright stars down to the fifth magnitude, is decidedly the handiest. The stars being arranged under their respective constellations, any particular star that is used can be at once turned to, which is not an easy thing to do in an ordinary catalogue where all the stars are arranged in order of Right Ascension, unless the Right Ascension is approximately known. Webb's "Celestial Objects" can be used in the same way. We will suppose, on opening the dome, Leo happens to be visible through the shutter; and on turning the tele-

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scope on γ Leonis, it is found by the R. A. circle to be about fifty minutes west of the meridian. By referring to either of the books above mentioned, it will be seen that the R. A. of that star is $10^h\ 13^m$. Evidently, then, the sidereal time at that moment is $11^h\ 3^m$, and the watch is made to indicate that time. It will be well to repeat the operation (on the same star) to avoid mistakes; and, if necessary, it can be checked again later in the evening. Of course, the watch may be regulated to keep sidereal time if desired.

Particular pains should be taken to see that the object-glass is properly placed in the tube with reference to the axis of the telescope. A very small amount of tilting will put a first-class object-glass on a level with one of very indifferent defining qualities. Selecting a fine night, the appearance of a bright star, near the zenith, under a high power, will show at once whether any change is required. If the star is not round and sharp, and the rings of uniform brightness and appearance, the proper correction should be made with the adjusting screws by raising one side of the object-glass. A single turn of a fine screw will produce a marked effect on the appearance of a close star when examined with a fine object-glass. In one case it would be difficult to say whether the star was really double at all; in the other it would be beautifully separated, with sharp, clean-cut discs.

It has been said that "a small aperture may sometimes show a very delicate and close companion to a bright star, where a large aperture fails to do it." This may be true of a refractor and a larger reflector; or of two reflectors; and certainly would be true of an excellent object-glass and a larger one of not good definition; but it is simply impossible with reference to any two first-class object-glasses of the same quality. The power and usefulness of telescopes for difficult double-star work is exactly in proportion to the apertures, other things being equal. The larger telescope will show a difficult object, which it will be impossible for the smaller to show under the same circumstances, and this will be found to be invariably true of all double-stars (and probably of everything else), no matter

what the magnitude of the companion is, or its position with reference to the primary. I shall be glad to be informed of any double-star, visible with less than six inches, which my instrument of that aperture fails to show, or any pair which can be seen better with a smaller glass than any one of the several Clark's refractors I have used in my observations. It may be that with a very unsteady air nothing will be lost by cutting down any large aperture, as difficult objects could not be observed in either case, but I very much doubt if anything will be gained even then with a good instrument. If any improvement is effected under ordinary atmospheric conditions by reducing the aperture of an object-glass or mirror, it may be considered as conclusive evidence that the instrument is a poor one or to say the least, of imperfect figure. I have never seen a Clark teleseope of any size which seemed to require the use of any such expedient at any time. Webb says, "an object-glass of poor defining power may sometimes be improved by stopping out defects or contracting the aperture," and this is just the result that would be expected with an instrument of that kind; but it would be manifestly absurd, in using a fine object-glass, to expect to see with part of it what the whole would fail to show.

REFRACTORS AND REFLECTORS.

Without attempting to discuss the comparative merits of refracting and reflecting telescopes, it is sufficient to say that the recorded observations appear to indicate that the reflectors which have been much in use, and particularly those of large aperture, are wanting in that perfect definition which is so essential for double-star work. All the difficult double-stars now known have been discovered with refractors, and substantially all the micrometrical measures have been made with the same class of telescopes. The catalogues of Sir John Herschel contain a great number of stars classified as double, but, with few exceptions, they are of very unimportant character, and properly considered, not double-stars at all. Close pairs are almost wholly wanting. Although the observations were made with a large reflector, these catalogues contain no stars visible in this latitude which would be a test for a good

six-inch refractor. Indeed, with that aperture, many of the principal stars of these wide pairs of Herschel have been found to be close doubles; hence in the absence of all test observations, we must conclude, notwithstanding the theoretical advantages often urged, that the figure of the large mirrors most in use during the last half century was not sufficiently perfect to make them suitable for this class of work. These remarks are based entirely upon what these instruments have done and have failed to do, as shown by the published observations, and not upon any personal experience with this form of telescope. Some of the comparisons seem to show that with small apertures, the difference in favor of refractors is not very great. A single half-hour on any good night would be sufficient with any mirror above twenty-inch aperture, to make discoveries of new and close pairs, which would show conclusively the character of the instrument with reference to definition. The discovery of a 0.2″ pair would tell more about the value of the instrument than could be learned from scores of testimonials from any source. Whatever opinions may be entertained of the relative importance of double-star work, the statement that the telescope which shows a very unequal and close pair is superior for any purpose to one of the same aperture which fails in such a test, will hardly be controverted, notwithstanding the inferior instrument may seem to answer all practical purposes in some kinds of work. The observation of nebulæ has been supposed to be work which any large aperture is good enough to perform, however unsuitable it may be for some other purposes; but it would seem to be quite as important here as anywhere else to have perfect definition, if details are to be correctly drawn and described.

DRIVING-CLOCK.

A good driving-clock is indispensible in using the micrometer, and very desirable for other purposes, and particularly when high powers are used. With a tangent-screw, position angles can be fairly measured, but very little can be done with distances without a clock. Bond's spring-governor is perhaps as good a regulator as any yet made, but the new rotary-pendu-

lum clocks, as made by Clark & Sons for their recent telescopes, are much simpler, and less liable to get out of order, and are less disturbed by a varying resistance. Without a steady continuous motion, measures of distance are so troublesome, particularly of difficult pairs, as to be entitled to but little weight. It is frequently stated as an evidence of the excellence of a driving-clock, that it will hold a star on or near the wire for an hour or more. Such a clock may or may not, be satisfactory. It is important to know, not what it will do in an hour, but what it will do in ten seconds. A small gaining or losing rate is of very little consequence, provided the motion is steady and uniform from second to second. A clock with an ordinary escapement could doutless be depended on to hold a star for an hour or two as it was at the beginning, but would be utterly unfit for micrometrical work. A few seconds are sufficient ordinarily for each setting of the wires, but during that time the star and the wire must remain as near as possible relatively fixed.

THE MICROMETER.

It is as important to have a good micrometer as a good object-glass, for on that depends the accuracy of the measures. If a star can be well and certainly seen, it ought to be well measured. It is not enough that the screw should be perfect; and indeed, this is a very small matter compared with the arrangement for illumination. One can hardly imagine any respectable optician or mechanic turning out a screw so badly made as to lead to any serious or even appreciable error in the short distances usually measured, as most of the work will be within the limits of a single revolution of the screw; but opticians and instrument-makers do not use micrometers, and some of them appear to have strangely erroneous ideas of what is required for the proper illumination of the wires. There must be a provision for bright wires. I am aware that some eminent observers use a bright field exclusively, and claim for it better results. Such a preference would naturally follow a failure to secure just the right arrangement of light on the wires in color, direction, and amount. The light must be perfectly under control, and the wires

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easily reduced to the last stage of visibility when desired. Red light is the best for all objects, faint and otherwise. In the old Fraunhofer plan, the best effect is produced when the lamp is in a plane passing through the micrometer-screw and the optical axis of the telescope. A small change from this position will reduce the light on the wires. The lamp will require to be rotated until it is brought into this position, approximately, for the measure of the angle and distance of each star. I see no reason why not only just as good results should be reached by this method, but in a large class of observations, very much-better results. Everything depends upon the manner in which the illumination is managed. For bright wires, it is absolutely necessary that the eye-pieces should have a cap between the outer lens of the eye-piece and the eye, with an aperture, the size of which depends upon the power of the eye-piece, much smaller than the diameter of the lens.

A much more perfect plan, advised by the writer, has been executed by the Clarks and attached to the micrometers made by them for the Lick Observatory, Mt. Hamilton, Cal., and the Washburn Observatory, Madison, Wis. In this arrangement the lamp is attached to the movable part of the micrometer, and is carried around the position-circle by the motion of the wires in position-angle. The light passes through a hole in the end of the micrometer "box," and strikes the wires at right angles to them, and of course at right angles to the axis of the telescope. The lamp is so suspended as to be always in a vertical position, no matter what may be the position or direction of the wires, or the telescope itself. The light is therefore the same; not only in amount, but in direction, so far as the wires are concerned, under all circumstances. By turning the mirror, by means of which the light is reflected into the micrometer the illumination can be steadily reduced from the maximum amount until the wires become invisible. The field is perfectly dark, as no light can enter the eye-piece, except that reflected from the spider lines. By means of a glass slide, any color desired can be given to the wires, the intensity of which can be

varied at pleasure. A peculiar arrangement of the relative positions of the micrometer screw head, the bisecting screw, and the pinion for rotating the whole system of wires is also carried out in the micrometers referred to, which is of the greatest value in the saving of time and labor in making measures, and in securing better results by a uniform and naturally convenient method of observing with these two micrometers. I have made during 1881 more than one thousand measures of double stars, many of them of the most difficult class, and I cannot speak too strongly of the great practical value of these improvements. A full description of the micrometer of the Lick Observatory, with an engraving form a photograph, will be found in *Monthly Notices* of the Royal Astronomical Society for March, 1882.

In attaching the micrometer to the telescope, it should be turned before being clamped in its place, so that the reading of the vernier when the wires bisect a star in its passage across the field, shall be a little more or a little less than 90 deg., in order that the quantity to be added or subtracted from the angles taken shall be small, and not require the observed angles to be increased 180 deg. The micrometer being left on the telescope, the zero of position will not require to be determined very often.

The movement of the wires for measuring angles should be effected by a pinion, giving quick motion, rather than by a fine tangent-screw. The latter I have found too slow. All of my micrometrical measures at the Dearborn Observatory have been made by turning the frame holding the wires by hand, the tangent screw and clamp being removed altogether. It is important to place the wires quickly, particularly in measuring difficult objects. When the wire appears to bisect the two stars, the accuracy of the angle can be tested by moving it back and forth with the bisecting screw, placing the stars on each side of one wire, and between the two wires. It would be absurd to adopt any invariable rule for the measurement of either angles or distances. One might as well attempt to use the same power on all stars. The different classes of double-stars require different methods in measuring, and experience will be the best

guide. The micrometer-screw in measuring distances should be turned in the same direction on both sides of the fixed wire. This will eliminate any shake or slack in the screw, which the springs may not fully take up. For extremely faint stars near bright ones, a very narrow bar, which can be made of a piece of tinfoil, placed in front of the aperture in the collar holding the eye-piece, will be useful, but it is necessary that the eye-piece should have an independent movement over the system of wires, so that the wires can be placed behind the bar, or on either side of it. With such a provision, found in most micrometers, the presence of a bright star is not a serious objection to accurately measuring the faintest companion. In measuring distances, the bright star will be bisected by one wire, and then by the screw or pinion giving motion to the eye-piece, the bright star and wire bisecting it are run behind the bar and the other wire placed on the faint star. The bright star is then run back to see if it is still bisected, and the faint star examined again, and this will be repeated until the observer is satisfied with the result. I have found a bar of this kind much preferable to colored glass, or any provision for merely reducing the light of the bright star.

In a general way, it may be stated that in measuring stars not exceeding 2″ in distance, the highest power which the night will stand should be used. It will often happen that different powers will have to be used on different nights in measures of the same star. There is no objection to this, that I am aware of. Three powers will be sufficient for all ordinary purposes. It is sometimes difficult to tell, from any description of a faint companion, what power will best show it. It is well known that some faint stars are only well seen with a high power, and that others, differing in no respect to the eye, are only plainly visible with a very low power.

The amateur observer will not fail to notice a great improvement in his power to see difficult double-stars, after considerable practice in this class of work. It will not consist so much in any change in the sensitiveness of the eye, as in knowing how to look. Delicate stars

will be picked up, which in the earlier stage would never be noticed. It is doubtful if there is really much difference in the vision of observers ordinarily, other than that which comes from practice and an intense devotion to a particular line of work. It does not follow because one is successful in finding new stars in regions familiar to the telescope, that he can see more than others, but rather that by training and practice he has acquired the habit of at once detecting any peculiarity in the appearance of a bright star under examination, if it is a close pair; and of catching any minute point of light in the immediate vicinity. Another observer would perhaps see it quite as well when pointed out to him, but would not detect it independently. The same thing is true in all departments of scientific observation. Discoveries are made every day which it would seem should have been made long ago, but ninety-nine have overlooked what was plain enough to the hundredth passer-by, and was obvious to all when they knew all about it.

For the measurement of stars at very high altitudes, some sort of observing-seat is very desirable. I have found one made substantially after the plan described by Dr. Erck (*Monthly Notices*, Dec. 1875) to work very well. It is inexpensive, and is easily managed by the observer. The head can be raised and lowered the smallest distance necessary, and measures made with more comfort than even when the telescope is nearly horizontal. Two changes were made in the construction of the seat which it may be well to mention. The legs with castors attached were arranged to slide up and down in another set of fixed legs forming guides, so that the whole seat could be raised about two feet above the ordinary position, thus allowing the seat to be used at considerable distances from the zenith. Instead of a pawl and ratchet to hold the hand-wheel in place, a thin piece of elastic wood was screwed to the frame so as to press gently against the rim of the wheel. A slight pressure, which in no way interferes with the turning of the wheel in either direction, is sufficient to firmly hold the movable part of the back in any position. The only drawback to the use of such seats is the inconvenience of reading the micrometer, and recording the observations.

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For all positions of the telescope, except when the tube is nearly vertical, the observing seat devised by Professor George W. Hough, an illustrated description of which will be found in *Monthly Notices* for March, 1881, is practically perfect. It is exceedingly simple and inexpensive, is readily moved about on the floor, and the seat can be changed instantly from any position to any other place on the chair. It is far superior in every respect to any plan heretofore suggested. The complicated contrivances which have been in use at different observatories, in which motion is given to the seat by endless chains, tangent-screws, gearing, cranks, etc., are much worse than the roughest and most primitive form of seat that could be thrown together, for any work requiring frequent changes of position. The new observing-chair referred to has been thoroughly tested at the Dearborn, Washburn and Lick observatories, and has been found to completely answer every requirement.

An ordinary "bull's-eye" lamp I have found to be superior to anything else for the observatory. It can be closed at once, or, without doing that, the light can be turned to one side so as not to interfere with delicate observations; and for reading circles it is the best and most convenient form. For the micrometer, a lamp with a small round wick, using kerosene, is better than an oil-lamp, as it can be turned up or down in an instant, never needs trimming, and will give a good light as long as a single drop of the fluid remains. It is more easily blown out than an oil-lamp, and on windy nights must be enclosed to avoid annoyance in this respect. If the observatory is supplied with gas, a light rubber tube run up the side of the pier, over the intersection of the polar and declination axles, and then down the tube to the micrometer, will be found the most convenient, and if the rubber tubing is properly attached, no reversing or changing the telescope will disturb it.

WHAT TO DO.

It may be stated in a general way that double-star work, to possess any considerable permanent value, must be in one of two directions; first in discovering

new double-stars, and secondly, in making micrometrical measures of doule-stars already catalogued. Of course, by looking up special objects, notes may be made with reference to magnitudes, colors, etc., but such estimates, unless by observers of considerable experience, have no great value. For the discovery of new stars, an instrument of not much less than six inches aperture will be necessary; but whatever the instrument is with respect to size, it must be of the best definition. If defective in that respect, it will be useless for the purpose. What can be done with a six-inch aperture, my published catalogues of nearly 500 new double-stars will show. This instrument has been dismounted here for the last two or three years, but during a few weeks in the autumn of 1879, when it was set up in California, some forty new pairs were discovered, a number of them being naked-eye stars. The opportunity for the discovery of new pairs is practically as good as it ever was. It is a very rare occurrence in my observations to pick up one of the pairs previously found. All that is necessary for this work is a good instrument, and good weather. My experience is, that it is impossible to avoid finding new pairs when prosecuting any line of double-star work under these conditions, and that a pretty good way to discover new systems is not to look for them specially. After making a measure, it has been my practice to examine the neighboring stars, and particularly those most prominent in the finder, and in this way I have detected some of the most interesting of those catalogued.

NEW DOUBLE STARS.

Unless the conditions are sufficiently favorable to allow the use of a power of at least 200 on a six-inch aperture, it will usually be a waste of time to attempt to find anything new. Some judgment should be exercised in reference to what properly constitutes a double-star that is really worth preserving. Of course, much depends on the magnitude of the primary, as well as the distance of the components. The extreme limit of distance has been gradually narrowed down in the successive catalogues of new stars. Many of the stars in Sir William Herschel's wide classes are several minutes

of arc in distance; Struve rejected all pairs exceeding 32″ in distance; Otto Struve narrowed the limit down to 16″, and in my own catalogues it is still further restricted, except in special cases. Prof. Ormond Stone of the Cincinnati Observatory, rejects all pairs "having a distance of more than 32″, or a magnitude for the principal star of less than 8, and the stars having a distance greater than 16″ where the magnitude of the companion is less than 9, unless included in the following formulæ:—

$$m + m' = 19 - \frac{D}{5}$$

where m and m' are the magnitudes of the two components, and D the distance in seconds."

The practical application of this in all cases is not entirely clear, but it seems to me objectionable for two reasons; first, that it extends the limits too far, and secondly, that it discriminates against very unequal pairs, or stars having very small companions, and would, in fact, reject altogether some of the most interesting pairs, however close, where the sum of the magnitude was not less than 19. I do not see any sufficient reason for varying the limiting distance on account of the magnitude of the companion. One would hardly regard the satellites of Mars as less important than the satellites of Jupiter because they are so much fainter, and certainly would not reject them on that account. There is but a slight chance of finding physical systems where the distance is considerable, and if it be assumed that the brightness of stars is in proportion to their distances, any change due to the proper motion of the bright star could be as well determined, to say the least, by measuring a faint star.

With some experience, the observer will be best governed by the appearance of the pair; but as a general direction I would suggest the following formula as a guide for the selection of new pairs of sufficient importance to be catalogued, m being the magnitude of the principal star and D the maximum distance:—

$$\left\{9.3 - \frac{9m}{10}\right\}^2 = D.$$

This formula is the most valuable in its application to the lower magnitudes, and, with rare exceptions, all new pairs exceeding the distance indicated should be discarded. Rejecting small fractions in the telescopic stars, and using round numbers for the bright stars, we have the following limiting distances:

Magnitude.	Distance.
10	1.0
9	1.5
8	3
7	9
6	15
5	25
4	35
3	45
2	55
1	70

One of the advantages of such a limit is that with the extreme distances allowed, the small pairs are likely to be quite as important as the brighter. Indeed, a tenth magnitude pair of stars of one second distance would almost certainly be of greater interest than any of the larger magnitudes with half the allowable distance. A 1″ pair should be saved in all cases, however faint the components may be. Of course, a telescope of moderately large aperture will be necessary to detect objects of this class. The double companion to *Mu* Herculis and *Beta* 679 are good examples of this class, the last being much the most difficult, and the closer of the two. In the large stars new components will necessarily be very close unless they are extremely faint. In the latter case, if distant, they will be interesting chiefly as test-objects. Something will depend upon the magnitude of the large star. Evidently a 30″ companion to Sirius would be of much more interest than a similar attendant to a less prominent star. It may be well to save a distant companion when it is nearer than one previously measured, although otherwise not important. This will happen most frequently in the wide pairs of Herschel I., but occasionally with the Struve stars, which may be outside the limits of distance given here. Such companions, however, will always lack the importance which belongs to a physical system. Most of the interesting binaries will be found in pairs under 2″ in distance, and particularly those in rapid motion.

With practice, and a familiarity with the more difficult stars already known, it is easy to tell what is

probably new, even before examining the catalogues. In my "Third Catalogue of New Double-Stars," I have shown that with a six-inch aperture more than one-third of the stars picked up, which were supposed to be new, proved to be so. With a larger aperture, the proportion of old stars among those suspected from their difficulty to be new, would be still smaller. With the 18½-inch refractor, I think it would be safe to say I can tell at a glance four times out of five whether a pair is new, provided it is not found in some of my own catalogues.

A word of caution may not be out of place with reference to seeing and not seeing difficult objects. It is very common for some observers to speak of "glimpsing" faint stars. Just what is meant by this term, I do not know. Practically it seems to mean, in many instances, that nothing at all is really or certainly seen. One may suspect the existence of a very faint star, or he may see it, but there is certainly no middle course. If it is seen, there can be no doubt about it, and there can be no mistake in the observation; if only suspected, there is nothing to be said about it until that suspicion is verified; and if there is any difficulty in verifying it with the same instrument in repeated trials, it is generally safe to conclude there is nothing there. It is one of the things passing all explanation, how any observer, experienced or otherwise, can permanently deceive himself; and still more difficult to understand how another class of persons can see with the greatest ease and certainty the same purely imaginary stars. This happened so frequently in the alleged discovery of companions to prominent stars, that one naturally looks with some distrust upon the announcement of new stars confirmed in this way. These discoveries are always made with small, or second-class instruments, and generally by astronomers with little or no experience in this kind of work. It is very seldom that double star observers are deceived, and when it has occurred, the error has been found, and frankly admitted. It is worthy of remark that the observers who are so successful in seeing stars which do exist, never find any real, new double-stars, and very rarely make any useful observations of diffi-

cult objects of any kind within the range of their instruments. It will be a prudent course for the amateur observer, when he thinks he has found a new star in the Trapezium of Orion, or a new companion to Sirius, Vega, ε Lyræ, or any star likely to have been closely examined before with large instruments, to carefully conceal the observation from his best friends until he is sure of his ground; and as a preliminary step towards testing the reality of his discovery, let him examine a dozen or more of the most difficult objects of this class about which there is no uncertainty, and see what success he has in seeing them. I think I may venture to recommend as particularly appropriate for this purpose many of the double-stars given in my catalogues of new pairs published from time to time, and especially the list given in the "Memoirs of the Royal Astronomical Society," Vol. XLIV. New stars, if they have any existence outside of the imagination of the observer, will always keep well, and the discoverer will lose nothing by delaying the announcement until he has repeatedly verified, and measured, if possible, the new object. From the non-observance of this rule, a great deal of time has been needlessly wasted in looking for the supposed new stars, about which nothing should be said in the first place.

[TO BE CONTINUED.]

THE AMERICAN STANDARD TIME COMPANY.

F. W., WASHINGTON, D. C.

In a recent number of *Knowledge*, an English magazine, edited by R. A. Proctor, we notice that an influential company for the distribution of standard time has been organized in this country, to be known as the "Standard Time Company." Messrs. Marshall Jewell, Charles E. Mitchell, Morris F. Tyler, and Robt. W. Willson as the directors of the company. It seems that this organization has been made for the purpose of synchronizing clocks, and that an expert has been examining the methods in use at home and abroad.

The system in use in London, patented by Barraud and Lunds, has been decided upon as the most successful, and the company has taken out patents to include the whole of America as well as the United States, "and an effort will be made to bring about a concerted system of time signalling over the whole of the States; local affiliated companies are to be formed, etc."

As yet no description of the apparatus to be employed by this company in synchronizing clocks has appeared in this country. As this system will undoubtedly come into general use by the railroads, manufactories, and mills, we give a brief account of it, part of which is taken from Mr. Lunds' own paper on the subject:

Electric clocks in general can be divided into three classes, namely—those driven by electricity, controlled by electricity, and those set by electricity. Although numerous patents have been issued in this connection and many more devices have been invented and used only by the inventor, yet until now all the efforts have been more or less failures. In fact such has been the general dissatisfaction with clocks of this class that electricity has been discarded in some places and other methods of control substituted.

The principal rival of the electric system is the pneumatic control. This was first established in Vienna and afterwards in Paris. Quite a good account of it has appeared recently in the *Popular Science Monthly*. This method is enormously expensive in comparison with the electric control, but it is more efficient. The Invention of Barraud and Lunds, however, leads the public attention back to the old and it seemed hopelessly imperfect method.

This new attachment can be applied to any clock and it is quite inexpensive. By this method clocks are merely set right at certain intervals, and it has nothing to do with the running of the clock during the interval. A pendulum clock with the second hand can not be well regulated by this method, as it is at present made public, but it is claimed that the regulation of railway clocks and others keeping minutes can be controlled as absolutely as mechanical skill will allow. Mr. Lunds says, in a meeting of the society of Telegraph Engineers

and Electricians, London, "My mode of setting clocks to true time is by one of these instruments which I call a synchronizer, and which forms an automatic finger and thumb to take hold of the hand at the right moment and put it at the beginning of the hour, ahead or back, in its right place." This is the whole principle. This thumb and finger is ordinarily open, but when the current is sent through a local magnet by the Observatory clock, the magnet by means of levers causes the fingers to come together and bring the minute hand to a fixed point, whether it is fast or slow of the true time. By a slight modification of the form and size of this little instrument, clocks of any kind can be regulated, and a dozen different patterns of time pieces may be found controlled by the same circuit.

If the observatory clock sending the accurate time signal fail to do its work, the controlled clock will not be interfered with, and the only result will be that until the next signal is received, the controlled clock will be in slight error; no more, however, than it would have been had it not been connected with the observatory clock.

Sir George Airy was the first to invent a "clock-setter" without any mechanical contact with the clock, but there were practical objections to this method. It is presumed that the "Standard Time Company" will shortly make public their plans. This is the first organized attempt at distributing time, and it is to be hoped that this company will devote some of its energy towards the simplification of the standards as well as the distribution of time.

ASRRONOMICAL NEWS.

STANDARD TIME.

The committee on Commerce of the House of Representatives has reported [Report No. 681] the following bill in relation to standard time:

"Be it enacted, etc., that the sum of $25,000 be appropriated, etc., etc., to provide for the expense of transmitting daily by telegraph the meridian time of the Naval Observatory at Washington, D. C., to all the

principal maritime ports of the United States, having a custom house, to United States Navy Yards and to State capitals and cities, having a population of not less than 15,000 inhabitants, when requested by the authorities thereof.

The Secretary of the Treasury shall erect a suitable clock and time-ball on the Custom House of each of said maritime ports and detail a person in each to attend to them at an additional compensation of $5 per month at each custom house for the extra work thus imposed. The Secretary of the Treasury is hereby authorized to pay for the same out of any money in the Treasury, etc., etc., *provided*, that no city other than a port of entry shall be furnished with a clock and time-ball, or keeper for the same by the Secretary of the Treasury. The said appropriation of $25,000 to be expended under the direction of the Secretary of the Navy."

The provisions of this bill need not be discussed now, as this is probably not a final solution of the question of standard time. It is perhaps worth while to point out that the "meridian time" (probably time of the meridian is intended) of the Naval Observatory will be altered when the new observatory is built, as the standard meridian of the United States is by law that of the Naval Observatory.

E. S. H.

DR. GOULD'S SOUTHERN ZONES.

The second volume of the Cordoba observations is at last printed. (Vol. I was the *Uranometria Argentina*.)

It contains the places of some 400 southern stars for the large catalogue of 30,000 southern stars, and also 128 zones, containing some 13,000 stars. This is the first installment of a very important work undertaken by Dr. Gould in 1870-71. This was to prepare a zone catalogue of the region of the sky from (and overlapping) Argelander's southern zones (which end at -31°) to (and overlapping) Gillis' zones, yet unreduced, which extend from the south pole to 25° S. P. D. and contain some 27,000 stars.

All the observations (1871-1881) are now reduced and they make a grand showing.

For the catalogue	121,000 obs.
Fundamental stars	14,000 "
In the zones	105,000 "
Total	240,000 "

About half of these were made by Dr. Gould himself. The total number of individual stars is about 80,000 in the zones and 30,000 in the catalogue. The individual observations of the same star made in different years agree well—the average discordance being below $0^s.10$ in R.A. and $2''$ in Declination.

One great obstacle to the rapid publication of these volumes is the printing, which has to be done in Buenos Ayres. A meteorological volume (Vol. II.) has also just been issued. Dr. Gould may be congratulated on the amount of work which he has accomplished in his ten years of exile. His uranometry, his catalogue of fundamental stars, his large catalogue of 30-35,000 stars, and his zones, make a showing of which any Observatory would be proud.

The state of our knowledge of the southern sky, so long an unknown region, is becoming satisfactory. The years 1870-1880 have seen great advances. At the Cape of Good Hope, the late Royal astronomer, Mr. E. J. Stone, has printed three catalogues of first-rate importance.

1st. The Cape catalogue of 2,892 stars (epoch 1840) from Maclear's observations (1834-40).

2d. The Cape catalogue of 1,159 stars (epoch 1860) from Maclear's observations (1856-61).

3d. The Cape catalogue of 12,441 stars (epoch 1880) from observations by Mr. Stone, (1870-1880); nearly all of Lacaille's 9,766 stars have been re-observed for this last catalogue.

From Melbourne we have a fine catalogue (epoch 1870) of 1,227 stars, from observations made by Mr. White (under the direction of Mr. Ellery, Government astronomer), since the observatory was moved from Williamstown.

Lamont's catalogue of 5,563 stars (many in southern declination) was published in 1874 and Yarnall's, which contains some 6,000 southern stars, in 1878. The next ten years will see the complete publication of Schoenfeld's *Durchmusterung* from $-2°$ to $-23°$; its

extension from -23° southwards by Stone, of Cincinnati, the publication of Gilliss' zones (from 0° to 25° S. P. D.) by Professor Harkness at Washington, and of Gould's 80,000 zone stars, and, very possibly, the publication in catalogue form of the Washington zones (1846-49) containing 38,000 observations. E. S. H.

STONE'S DURCHMUSTERUNG SOUTH OF -23°.

We learn from a recent letter of Professor O. Stone, director of the Cincinnati Observatory, that his *Durchmusterung* (or zone observation of all the stars from the first to the tenth magnitude inclusive) from -23° southwards, is progressing rapidly. The zones are 1° wide and four zones are nearly finished, so that printing may commence this year. Schoenfield's *Durchmusterung* (from -2° to -23°) is also nearly ready for publication. E. S. H.

REDUCTION OF THE RIGHT ASCENSIONS OF THE NORMAL SYSTEM OF PUBLICATION, NO. XIV. OF THE ASTRONOMISCHE GESELLSCHAFT TO NEWCOMB'S FUNDAMENTAL SYSTEM, (1870.)

A letter from Professor Newcomb gives the reduction of the Normal Catalogue above (Pulkova 1865), Auwers to Newcomb's system as follows:

$$N_2 - \text{Auwers} = +0^s.006$$
$$-0^s.005 \sin \text{R. A.} + 0^s.070 \left\{ \frac{\text{Year} - 1875}{100} \right\}$$

E. S. H.

The French Academy of Sciences has recently awarded the Lalande Prize to Dr. Lewis Swift, of Rochester, N. Y., for his discovery of seven comets in four years. One of them, Comet *e* 1880, which is identical with Comet III 1869, discovered by Temple, is a short-period comet. The Valz prize was awarded to Dr. D. Gill, Astronomer at the Cape, for his researches on the solar parallax, especially for his observations of Mars at Ascension in 1877.

XUM

OBSERVING-SEAT FOR EQUATORIAL.

BY PROFESSOR G. W. HOUGH, DIRECTOR OF THE DEARBORN OBSERVATORY.

In making micrometer measures with the equatorial telescope it is desirable to have a convenient seat for the observer. A person, in a cramped or unnatural position, can hardly do as good work as when the body is resting in an easy and natural manner.

The problem of a perfect seat for the equatorial, can hardly be said to have been solved, although a number of elaborate and costly chairs have been constructed by different observers. I presume the majority of those observing with an equatorial, use a simple step-ladder furnished with cushions for securing the proper elevation of the eye. This simple apparatus seems to be the most expeditious for actual work, notwithstanding the trouble of getting always in just the right position.

The Dearborn Equatorial was provided with an elaborate chair constructed after the model of that devised by Bond, for the Harvard University telescope. This piece of mechanism was found to be so unwieldy, and required so much labor to bring the seat in position, and withal, consumed so much time in its manipulation, that it practically has never been of any use. Nearly all observations have accordingly been made by the use of an ordinary step-ladder.

During the year 1880, Mr. S. W. Burnham and myself, decided that an adjustable seat attached to the step-ladder would add greatly to the convenience of the observer, and would also economize the time in preparing for micrometric measures. A light and easily manipulated chair is especially desirable for double-star work, since many different objects are often examined on the same night.

After considering the problem, the following mechanism was devised, which, after two years of constant use, has answered the purpose admirably. The accompanying drawing will clearly show the seat-mechanism.

Over the center of a step-ladder 11 ft. in height, and 5 ft. in width, are screwed two strips of pine, *s*, *s*, two

inches in width, which pass from the top to the bottom of the steps; the distance between them being about seven inches. A light wooden frame is made to slide on this track, to which the observing seat C, is attached. The seat is 20 inches in length and 12 inches in depth. In order to keep it in place, the strips, *s*, *s*, are beveled on the inside, with corresponding bevels in the sliding frame, analagous to the slide-rest of a lathe. The seat when in use is raised and lowered by the following device:

To the top of the steps, on the right-hand side, in the figure, is attached a woven cord ⅜ of an inch in diameter, which is passed *once* around a fixed wooden drum A, 5 inches in diameter, attached to the frame carrying the seat, thence over a loose pulley B, near the seat, thence back again to the top of the steps, over a loose pulley, not shown in the figure, thence over the weight pulley W; the end being fastened on the right hand side. The weight slides in vertical tracks, attached to the rear of the step-ladder and is just sufficient to balance the seat.

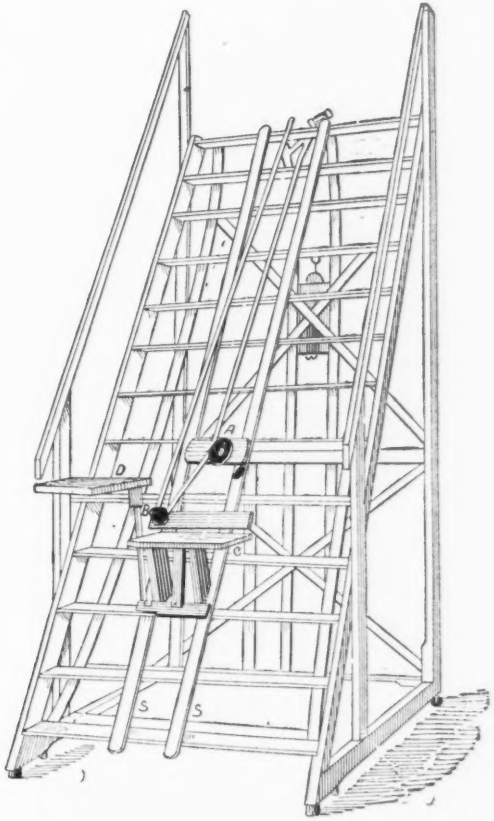
The seat, therefore, is held in position simply by the torsion-friction of the cord around the fixed drum A, without the use of any clamp or stop. The whole weight of the seat and frame is about 15 lbs., and a very slight force, viz.: 10 lbs., will cause it to slide up the track when unloaded.

When seated in the chair, a slight pull downwards, on the rope to which the counterpoise is attached, causes it to descend any amount desired.

As the whole merit of our apparatus consists in the ease and celerity with which the observer may secure the proper elevation for the eye, it may be added that the seat is completely under control; it may be moved one inch or a foot, almost instantaneously, and in this respect is infinitely superior to any screw or rack motion.

For the upward movement it is necessary to rest one's weight on the steps.

As there are no ratchets or stops, but simply a rope wrapped around a smooth drum, the chair can be manipulated in the dark without difficulty. The cost of applying this apparatus to the step-ladder was about five dollars.



When using the micrometer, a small table D, for holding the note-book, lamp, eye-pieces, etc., is attached on the side of the seat and may be moved at pleasure.

The step-ladder, itself, is mounted on castors and is easily shifted to any required position.

When micrometric measures are not in progress, the seat may be slid to the top of the steps, where it is out

of the way, and the ladder may be used in the ordinary way without inconvenience.

The following are the dimensions of our step-ladder and chair:

Length of steps, 5 ft.
Distance between the steps, 9¼ inches.
Depth of step, 7½ inches.
Height of ladder, 11 ft.
Depth of ladder, 6½ ft.
Size of upright frame, 3 in. by 1¾ in.
Size of hand-rail, 2½ in. by 1¾ in.

SEAT.

Width of back, 2 inches.
Seat, 12 in. by 20 in.
Table, 14 in. by 20 in.
Distance from seat to drum D, 18 in.

A step-ladder built to conform to the radius of the telescope, and provided with a sliding seat similar to the one described, could be mounted on fixed tracks so as to be always at the right distance from the telescope, but we doubt whether it would be as convenient as one moving over the floor in any direction.

HISTORIC NOTES ON COSMIC PHYSIOLOGY.

BY T. STERRY HUNT OF MONTREAL.

[ABSTRACT.]

The author began by insisting that general physiology, as the philosophy of material nature, is co-extensive with general physiography, in which sense it was employed by the best writers up to the first years of this century. In the abridgments of the Philosophical Transactions of the Royal Society up to 1700 and 1720, the chief division is into Mathematical and Physiological subjects, the latter including the phenomena of the three kingdoms of nature. There is a physiology not only of animals and plants, but of the inorganic world, and from terrestrial physiology we rise to a conception of the physiology of the Cosmos or

material universe, a subject which from the earliest times has attracted the attention of philosophers. One of the most evident of the problems thus presented is that of interstellar space and its relations to our earth and its gaseous envelope. After noticing the views of the ancient Greeks, the author referred to the discovery by Alhazen of the refraction of light, from the phenomena of which the Arab philosopher attempted to fix the limit of the terrestrial atmosphere. He then noticed the similar attempts of later observers, and adverted to the well known hypothesis of Wollaston, who endeavored to assign thereto an absolute limit on grounds which are inadmissable. He adverted to various views as to the so-called ether of space, which Newton thought must include exhalations from celestial bodies, and noticed the hypothesis of Grove, that the medium for the transmission of radiant energy through space is but a more attenuated form of the matter which constitutes the gaseous envelopes of the earth and other celestial bodies, between which, through this medium, Grove, like Newton, supposed material interchanges to take place.

The suggestion of Arago as to the possibility of determining the density of the rare matter of interstellar space was noticed, as well as that of Sir William Thompson, who has even attempted to fix the minimum density of the luminiferous medium which he, like Grove, conceives may be a rarified extension of the terrestrial atmosphere. W. Mattien Williams, adopting the hypothesis of the atmospheric nature of the interstellary matter, has attempted to show how the Sun in its course through space may condense this matter with the evolution of heat, and thus replenish the solar fires. From this ether also, by a stoichiogenic process the various chemical species are perhaps generated.

The author has endeavored to approach the study of interstellary matter from a wholly different side. From a consideration of the chemical and geological changes of which we have evidence in the earth's crust since the beginning of life on the planet, it is clear that great quantities of carbonic di-oxide have become fixed, partly in the form of carbon, with evolution of oxygen, and partly as carbonates—equal in the aggregate to 200 atmospheres or more. This enormous volume, it

is held, must have come from outer space to supply the gradual absorption of the gas from the atmosphere, while by a reverse process, of diffusion, the great amount of liberated oxygen may have been got rid of, and the equilibrium of the atmosphere in this way maintained. The consequences, both meteorological and geological, of this process were discussed by the author in 1878, and more fully in 1880, in an essay on "The Chemical and Geological Relations of the Atmosphere," in the American Journal of Science. As a further contribution to the history of these views, the author proceeded to show that Sir Isaac Newton not only held to the presence in interstellar space of exhalations from the sun, the earth, the fixed stars and the tails of comets, which he supposed to become diffused and to form part of the ether, but even suggested that this etherial matter is the solar fuel, and essential to planetary life. From a consideration of the processes of vegetable growth and decay Newton arrived at the conclusion that elements from inter-stellar space, brought by gravity within the terrestrial atmosphere, serve to nourish vegetation, and by its decay are converted into solid substances. In this way are, according to him, generated not only combustible (sulphurous) bodies, but calcareous and other stones, whereby the mass of the planet is augmented. These views, put forward in Newton's famous "Hypothesis Concerning Light and Color," in 1675, and in the "Queries to the Optics," are more definitely enunciated in Propositions 41 and 42, of Book III, of the "Principia."

ON A SIMPLE METHOD OF MEASURING FAINT SPECTRA.

BY WM. HARKNESS.

An ordinary spectroscope, having a sixty degree prism of dense flint glass, a telescope and slit-collimator of about six and a half inches focus and seven-eights of an inch clear aperture, and a photographed scale with its accompanying collimator, is sufficiently powerful

for the common reqirements of chemistry, physics and astronomy. Such an instrument has only one inconvenience, and that is the impossibility of measuring faint spectra with the photographed scale. After numerous trials, I have hit upon a method of overcoming this difficulty, which is so simple that I can scarcely believe it is new. A screw with a sharp point, and rather a fine thread, is inserted in the tube of the viewing-telescope in such a position that the point of the screw is visible at the focus of the eye-piece. In applying this to faint spectra, the point of the screw is brought up to the line to be measured while the field is perfectly dark, and then the photographed scale is illuminated and the position of the point of the screw read upon it.

TRANSIT OF MERCURY.

In September last I had some correspondence with Professors Newcomb, Hall and Holden as to the desirability of trying to get observations of the transit of Mercury from some station in the northern hemisphere to be used with those which might be made in Australia.

I decided to take my telescope of 6⅓ inches aperture to the Sandwich Islands, as being the most northern point from which the entire transit would be visible.

My results are as follows:

TRANSIT OF MERCURY,

on the 7th of November, 1881, at Honolulu. Lat. 21° 17′ 56″.3 north. Long. 10h. 31m. 27.3 sec. west of Greenwich.

Contacts.	Computed Nautical Almanac.			Observed Greenwich Mean Time.		
	h	m	s	h	m	s
1st	10	16	29.79	10	17	27.25
2d	10	18	12.62	10	18	25 75
3d	15	35	21.77	15	35	36.25
4th	15	37	04.79	15	36	28.25

I do not attach any weight to the observed times of 1st and 4th contacts.

I consider the 2d and 3d as being reliable.

The second contact is 13ˢ.13 later than computed time; the interval between 2d and 3d is 01ˢ.35 greater than the computed interval.

I used the full aperture of my glass, with a solar prism by Alvan Clark & Sons. Power 80.

I have received the following figures from H. C. Russell, Esq., Government astronomer, Sydney, Australia:

Lat. 33° 51′ 41″.1 south. Long. $10^h\ 04^m\ 47.3^s$ east of Greenwich.

Contacts.	Computed Greenwich Mean Time.	Observed Greenwich Mean Time.
	h m s	h m s
1st	10 16 26.70	10 17 10.23
2d	10 18 11.70	10 18 53.35
3d	15 35 40.70	15 35 37.86
4th	15 37 23.70	15 37 21.92

Mr. Russell puts 2d contact $41^s.65$ later than his computed time; and makes the interval between 2d and 3d contacts $44^s.49$ less than the tables given us.

Mr. R. T. Ellery sends me his observed times for the four contacts as taken at Melbourne, Australia. He does not send his computed data.

The computed times given below are my results for his station.

Lat. 37° 49′ 53″.4 south. Long. $9^h\ 39^m\ 54.8^s$ east of Greenwich.

Contacts.	Computed.	Observed.
	h m s	h m s
1st	10 16 22.92	10 18 49.26
2d	10 18 05.77	10 19 12.90
3d	15 35 41.39	15 35 38.61
4th	15 37 24.12	15 37 18.10

These figures put Mr. Ellery's 2d contact $01^m\ 07^s.13$ late, and show a difference of $19^s.55$ between the Melbourne and Sidney observations of this phase. According to my computations this difference should be only $01^s.55$.

The observations all agree in making the planet late in coming on to the disc of the Sun, while the agreement in the time of 3d contact is quite satisfactory, namely:

Honolulu ..... $15^h\ 35^m\ 36.25^s$ ..... Rockwell.
Sydney ..... $15^h\ 35^m\ 37.86^s$ ..... Russell.
Melbourne ..... $15^h\ 35^m\ 38.61^s$ ..... Ellery.

Charles H. Rockwell.

Tarrytown, New York, March, 1882.

SOLAR AND AURORAL COINCIDENCE.

From The Dispatch (Pa.)

Most of your readers must have been eye-witnesses of the remarkable auroral display of last night and this morning. The auroral streams converged from all parts of the horizon (except from southeast to southwest) to a point about ten degrees south of the zenith, a direction which they maintained with remarkable fixity for some hours, while the fluctuating light seemed to pour upward incessantly, like a pale flame rising from a more fixed brightness, near the horizon, which in the north, at least, was intense enough to cast a well-marked shadow.

My object in writing is not so much to describe the aurora, however, as to call attention to the fact of its coincidence with a remarkable sun-spot, which is now visible to the naked eye, if defended by a smoked glass.

The spot, which made its appearance a few days since, has not yet reached the centre of the Sun, and it is as yet uncertain whether it has attained its full size. Such as it is, however, we have had no such solar visitant for over ten years. It consists (at the time I write) of two large and five small nuclei, united by penumbræ, which are traversed by "bridges" of intense brightness. Its area may be given in round numbers, at a minimum, as a thousand million of square miles, and the extraordinary forms within the area of this inconceivable disturbance are so interesting that I have wished to direct to it the attention of your readers in connection with the recent auroral display, of which it is not impossibly the cause.

The occult nature of the relation between spots on the distant Sun and the aurora, which seem to flame but just above our house-tops, is still one of nature's most hidden mysteries. That there is such a probable relation, however, such occurrences as this constantly remind us. S. P. LANGLEY.

ALLEGHANY OBSERVATORY, April 17.

CINCINNATI.

At the beginning of the year there were connected with the observatory, Mr. H. V. Egbert as temporary assistant, and Messrs. H. C. Wilson and F. P. Leavenworth as students in astronomy. On the 1st of September, Mr. Egbert having resigned, the vacancy was filled by the appointment of Mr. Wilson. Mr. Leavenworth has been absent on leave since the 12th of the same month. During the latter half of the year, assistance has also been rendered by a private pupil, Mr. John Jones.

With the 28 cm. refractor, positions of the following comets were determined:

Comet 1881, III on 29 nights.
" 1881, IV " 13 "
" 1881, VI " 2 "
Encke's " 2 "

Observations for which the positions of the comparison stars were known have already been published, (Astr. Nachr. No. 2408). The positions of the tails of Comet III. were determined on a number of nights with the naked eye, and with the aid of an opera-glass. The position-angles of the jets in the coma were determined, and sketches made, when the comet was nearest its perihelion. The most remarkable phenomenon observed was the great outburst (first seen by Mr. Wilson), and the detachment of a portion of the nucleus, which occurred on the 6th of July.

The Sun was examined by Mr. Given on 145 days. Spots were visible on each occasion.

The 10 cm. equatorial has been devoted to a continuation of Argelander's and Schoenfeld's *Durchmusterungs*, from 23° to 31° south declination. The observations are, in general, made in zones a degree wide and an hour long, and recorded on a chronograph. In this way it is hoped a larger number of stars may be obtained, and with greater deliberation. The zones are arranged in two classes, such that in the one the zero falls near the beginning, and in the other near the middle of the degree. Each star is thus observed twice, but in such a manner that if it lie near the edge of the

zone at the first observation, it will be near the center at the repetition. The magnitudes are all reduced to a common standard by the comparison of each zone by Argelander.

During the year 95 hours were observed involving 32,726 determinations of position. At the end of the year, 72 whole-degree and 77 half-degree zones had been observed; in all, 149 hours, leaving 259 hours still to be observed.

With 7 cm. transit instrument, observations were made on 78 nights for the regulation of the standard time of Cincinnati. The standard clock had been encased in November, 1880, and its rate greatly improved thereby. In addition to time-signals hitherto given, another time-ball has been dropped, since the 18th of July, near the center of the city.

On a number of evenings in October, signals were exchanged for the determination of the difference in longitude between this observatory and Las Animas, Colorado.

The library has increased during the year by the addition of 396 books and pamphlets, principally by donation. ORMOND STONE.

NASHVILLE.

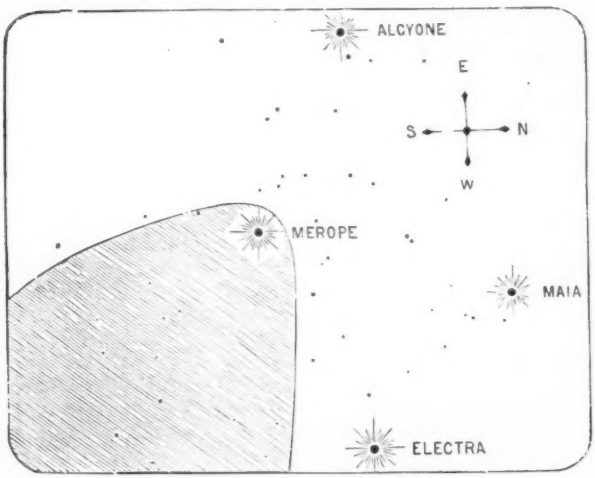
E. E. Barnard, of Nashville, Tenn., has done creditable work with a five-inch equatorial during the last year. Positions of all the comets were taken. Oct. 21, at $4^h\ 30^m$ Encke's comet was observed to pass centrally over a ninth magnitude star without diminishing its brightness at all; indeed, the star to Mr. Barnard's view seemed rather to be projected on the head of the comet. Concerning the discovery of comets, he says:

"On the morning of May 12, 1881, a small nebulous object was found; the next morning it was seen again near α Pegasi, and it proved to be a comet with slow motion toward the northwest. It was announced on the morning of the 13th, but after that it was lost, and could not be found again.

"September 17, I discovered another small comet (*e* 1881). As it set very soon after the sun, its position

was obtained only approximately. It was again seen on the following night, and announcement of it was then made. It was difficult to get good observations of the comet, because it was so near the sun. It was not found in Europe until Oct. 1, by the aid of an ephemeris computed by Mr. Chandler of Boston, and cabled to the Dun Echt observatory by the new cipher code of the 'Science Observer.' The orbit of this comet does not resemble that of any other known.

MEROPE NEBULA IN PLEIADES.



R. A. $3^h\ 38^m$. Decl. $+ 23^\circ\ 20'$.

The above drawing was made by Mr. Barnard, and it shows the relative positions of about 50 stars and the nebula. The relative distances of the objects are eye-estimates only. Many small stars, and some prominent ones, in the same field of view, are purposely omitted. No attempt has been made to give the small stars relative prominence according to difference of magnitude; but the object of this cut is simply to show the relation of the nebula to its starry neighborhood. It should also be said that the nebula is much more prominent in the drawing than it appears to be in the telescope; this was almost a necessity in preparing a drawing of this kind. In the telescope, those who

have seen it say that it appears like a faint haze stretching out and overlapping *Merope*, in a southwesterly course, until quite lost to view in outline.

It will be remembered that this nebula was discovered at Florence, by Mr. Tempel, in 1859. Since that time a number of other observers have seen and described it. Trouvelot reports that it is variable, and that it has become very faint since 1880, and that it can now be seen only by those acquainted with its former appearance. Mr. Barnard says: "It is plainly visible in my five-inch refractor, and that it has been seen with a 2½-inch telescope, in the presence of the light of a quarter-full moon. My chart of *Merope* and stars near it is identical with Tempel's drawing, in regard to position, although the latter was not seen until after my sketch was made. Mine, however, does not agree altogether with that of Mr. A. A. Common of England, made by the aid of his 37-inch mirror of silver-on-glass. Being interested in this object, I have made inquiries of a few observers concerning it. One delineates it as I do; another cannot see it with a telescope of any aperture between four and thirteen inches. Professor Swift sees it as I do, even with two inches of aperture. Observations will be continued to detect variability.

Messrs. Wm. Bond & Son have seldom exhibited their instruments in competition with others, but whenever they have done so, they have invariably received high awards. In 1851 at the World's fair in London, they received one of the twelve Grand Council Medals awarded to this country, and they have also received the gold and silver medals of the Mass. Char. Mech. Ass., at the exhibitions in 1850, 1856, 1869, 1874, and the silver medals of the Paris exposition in 1867, being in each case the highest prize awarded in their department.—(*See advertisement elsewhere*).

The Standard Time Company, of New Haven, Conn,. are the sole owners, for America, of the Barraud and Lunds' patent, relating to synchronized clocks.

EDITORIAL NOTES.

It is believed that the changed dress of the MESSENGER will be gratifying to its friends, although circumstances attending the step have caused unexpected delay.

Some time ago, an article appeared in an English scientific periodical from the pen of Mr. S. W. Burnham, of Chicago, on methods of observing double-stars. The theme was treated so well and so fully, that it seemed most desirable to give it wider circulation in America; and so it was asked for publication. Mr. Burnham not only kindly consented, but also re-wrote much of it, and added new points of special interest. The paper in part is presented in this issue, and a careful perusal of it will be profitable to any person interested in double-star astronomy.

The new comet discovered March 18, at Dudley Observatory, Albany, N. Y., by Mr. Wells, promises to be an object of marked interest. When first seen, it was described as having a round, well-defined nucleus, of the brightness of an eighth magnitude star, with a narrow train 6′ long. Its light, March 17, was taken as unity, and Mr. Egbert's ephemeris shows that its brightness will increase rapidly until it reaches the perihelion of its orbit, at which point others say its light will be more than 3,000 times as great as at the time of its discovery. If the nucleus then be active, because of its near approach to the sun, the tail may be large, and the comet generally offer favorable opportunity for physical research.

Professor Hall of the Naval Observatory at Washington, under date of April 14, says: "It is to be hoped that careful observations of the tail of this comet will be made. Estimates with the naked eye, opera-glass or comet-seeker, of the position and length of the tail will be valuable. The position should be platted on a good star-map. Professor Frisby has observed the comet here, and has computed a set of elements. He makes the perihelion passage June 6, and the distance from the Sun at that time only three millions of miles. Since this comet was found at great angular distance from the Sun, its angular motion during the time of the observations has been small, and the elements must be rough."

The following are Mr Egbert's elements as recently published in the *Science Observer*:

ELEMENTS.

Perihelion Passage, 1882, June. 10.3076, Greenwich M. T.

Long. Perih	51°	04′	21″	Mean Equinox, 1882.0
Long. Node	204	43	11	
Inclination	73	38	44	
Log. q	8.763698			

EPHEMERIS FOR GREENWICH MIDNIGHT.

		R. A.			Decl.		
		h.	m.	s.			
1882	May 1,	20	38	13	-68	49. 4	
"	" 5,	21	37	53	72	22. 2	
"	" 9.	23	04	03	74	26. 9	
"	" 13,	00	44	33	73	58. 9	
"	" 17,	2	09	15	70	47. 2	
"	" 21.	3	07	00	65	39. 3	
"	" 25.	3	44	34	59	20	
"	" 29.	4	09	43	52	11	

WASHINGTON.—The plans for the new Naval observatory have been decided upon, after a very careful consideration by the gentlemen to whom they were submitted.

The general form is in shape like the letter T, with a frontage of about 180 feet, facing north: with domes for two equatorial instruments at one end, and slits for two transit instruments at the other.

The dome for the 26-inch equatorial is at the extreme southern end of the projection from the centre of the main building.

A bill, asking for about $550,000, is now before congress. This sum will enclose the grounds of about seventy acres area, make the necessary roads and approaches, build the new observatory and move the instruments to it.

The site chosen was formerly known as the "Barber place." This was bought last year for about $65,000, this sum covering also all expenses for surveys, maps, examination of title, etc.

The general idea for observing the transit of Venus seems to be to utilize the outfits procured in 1874, and not to go to much additional expense.

There are eight of these sets of instruments, each including an equatorial of five inches aperture, a transit of the Russian or "broken-back" form, and the necessary apparatus for taking photographs.

Most likely four parties will be stationed in our own country, somewhere along a line running from Washington to Texas, one station at the cape of Good Hope, one on New Zealand, and two well south on the coast of Chili.

BALTIMORE.—At the Johns Hopkins University can now be seen in operation the most perfect ruling engine ever constructed. The largest gratings yet made are 3¼ inches diameter, with thirty thousand lines to the inch.

They are ground in a concave form, with a focal distance of about twenty feet, thus concentrating the sun's rays without being obliged to use a lens. Gratings of 4½ inches diameter, have been cast and will soon be ruled.

This engine was constructed on a plan devised by Professsor Rowland and Dr. Hastings of the J. H. University.

A few months ago, Dr. C. S. Hastings finished another object glass on curves determined by his own method. This glass of 9.4

inches diameter has been subjected to the most delicate optical tests, and has proved itself to be as nearly perfect as anything human can be. It was shown last autumn to the Cincinnati Industrial Exhibition, and was awarded a silver medal.

Dr. Hastings determines the optical qualities of the disks by means of a careful study of test prisms, cut from each piece. He uses these indices as constants, combined with variables representing the radius of curvature of each of the four surfaces, the focal length and the distance between the two glasses. He works out this equation to give the best color correction, and then grinds the disks to the radius thus obtained. The mathematical part of this system is intricate and tedious; but when the several radii are obtained, the work is practically finished, as the 9.4-inch glass above mentioned was ground and polished *in one week* after being taken in hand by the grinder. The accuracy of the curves is tested by a careful study with the spherometer.

This is the third glass ground by Dr. Hastings on this theory, and each time he has been rewarded by a practical confirmation of its correctness.

PITTSBURGH.—At the Allegheny Observatory, Professor Langley is continuing his investigations of heat in the different parts of the solar spectrum.

Of late years refracting telescopes have been much more prominent than reflectors, and some of our readers may not know that instruments of the latter class, and of very excellent quality, are made in this country.

Mr. John A. Brashear of Pittsburg had the astronomical instinct in him, (as one has jocosely said,) and worked on glass reflectors while still a foreman in one of the large rolling mills in the smoky city. He has now taken up the manufacture of reflecting telescopes, as a business, and has many very complimentary letters from astronomers in different sections of our country, to whom he has sent his instruments. At an early date something more definite will be said of his instruments and his skill as a maker of reflecting telescopes. See his advertisement on a cover page of this number.

From the British Navy estimates for 1881-2, the following items of interest are extracted: "*Greenwich Observatory*, total, £5,144. The salary of the Astronomer Royal, (to be reconsidered on the appointment of a successor to Sir G. B. Airy) £1,200; of the chief assistant, £600; two first class assistants, £787; four second class assistants, £1,017; expenses for repairs, apparatus, etc., £2,639. *Cape of Good Hope Observatory*, £2,703, total estimate for salaries, apparatus, etc. *Nautical Almanac*, £3,203, including salary of the superintendent, £550. The average annual sale of the almanac for the last five years is estimated at 16,749 copies. The

Chronometers of the Royal Navy cost £1,432, and the expenses of the *Compass Department* are £2,146.

The Harvard college observatory is about to print a volume containing the micrometric observations made with the fifteen-inch equatorial during the years 1866 to 1882. The new meridian photometer has been received, and promises excellent results. Its aperture is four inches.

ASTEROIDS.

The discoveries, of the year so far have been:

No.	Name.	Discoverer.	Observatory	Date.	Discoverer's No.	Mag.
221	.....	PALISA,	Vienna	1882, Jan. 19	30	?
222	.....	PALISA,	Vienna	1882, Feb. 9	31	?

The following planets have lately been named: 212, *Medea;* 216, *Cleopatra:* 218, *Bianca;* 219, *Thusnelda.*

Why do not some of the discoverers go to the Aztec pantheon, which would give a large number of beautiful names? Take for example, Chalchihuitlicue, the sister of the Aztec rain-god, and herself the patroness of "salt, dirt and immodesty." We commend this suggestion to the industrious and energetic discoverers of planetoids.

Professor Folie, director of the new Observatory at Luttich, has published new tables for computation of the precession, nutation, etc. These are more complete than Coffin's and Hubbard's tables in the Washington observations for 1847, and according to the account of them in V. G. S. der Ast. Gesell. 1881, p. 291, they are also more convenient, as the argument (R. A.) does not vary uniformly, as in the Washington tables, but is varied so as to make the interpolation easy. E. S. H.

The German Astronomical society is about to issue another volume of its publications (the quarto series). It has for title, "Syzygien-Tafeln fur den Mond, nebst ansfuhrlicher Anweisung ihres Gebrauchs, von TH. von OPPOLZER."

ZONE OBSERVATIONS.

In Bessel's Southern Zones (+ 15° to − 15°) and Northern Zones (+ 15° to + 45°) there are 75,011 observations of 62,000 stars. The actual time spent in observing was 868 hours 18 minutes, so that on the average a star was observed every 41ˢ.7, or at the rate of 83.64 stars per hour. Two observers participated, Bessel and Argelander. In Argelander's Northern Zones (+ 45° to + 80°) there were 26,424 observations of 22,000 stars. The actual time required was about 320 hours, and an observation was made every 43ˢ.6 on the average, or at the rate of 82.56 per hour. In Argelander's Southern Zones (− 15° to − 31°) there were 23,250 observa-

tions of 17,600 stars. The time employed was about 281 hours. On the average an observation consumed 43^s.5, or the rate was 82.75 stars per hour. In Argelander's, as in Bissell's zones, two observers participated.

In the Washington zones (1846-49) only one observer was employed at each instrument. The rates are as follows: Meridian Circle Zones, 1846, 4,137 observations were made in 178^h 19^m, or at the rate of 23.20 per hour; Meridian Circle Zones, 1847, 1848 and 1849, 7,388 observations were made in 227^h 30^m or 32.52 per hour; Transit zones, 1846-1849, 12,029 observations were made in 395^h 55^m, or at the rate of 30.37 stars per hour; Mural Circle Zones, 1846-1849, 14,792 observations were made in 500^h 27^m, or at the rate of 29.55 stars per hour. E. S. H.

A very interesting report is published by General H. M. Abbot, of the corps of engineers U. S. army, on the astronomical work which has been done during 1881, at the engineer post of Willet's Point, New York Harbor. It is to this school of application that young officers of engineers are sent, to learn the practical application of their studies at West Point. They are taught the practice of military surveying, mining, torpedo service, etc., etc., and also the application of astronomy to military and boundary surveys. Each year a general order is issued, giving the results of the past year's work. The order for 1882 may be summarized as below:

Observations for Local Time.—Each officer makes a long series of such determinations with various instruments, and in various ways. Using the portable transit, the time of transit is at first recorded by an assistant, at the word given by the observer, next, the observer records his own time by the *relay beat* of a chronometer every 1^s; next by the chronographic method, and lastly by the beat of the chrometer itself (every 0.5 second). Beginners use these methods in succession in the order named.

Personal equation is studied by means of Eastman's machine (see Wash. Ast. Obs. 1875) and an interesting table of results by the second method of marking time (the relay beat) is given.

The time determinations are given for each day of observations with the probable errors.

Time determinations by sextant observations are also given, and by means of the (known) correction of the standard chronometer, the error of each observation and observer is determined.

We quote below the errors of the sextant *Delta* t's so determined. (Usually 10 altitudes of an east star and 10 of a west were employed) 4^s.0; 1^s.0. 1^s.5; 13^s.7; 8^s.2; 24^s.1; 1^s.7; 0^s.4; 1^s.8; 0^s.7; 3^s.3; 2^s.8; 5^s.6; 5^s.0. Of course these are the observations of students.

Observations for Latitude.—The latitude is determined first by zenith telescope, and the first process is the valuation of the level

division. This is done by each student, and of the set for 1881 the largest probable error is ± 0.″008.

The observations for latitude are given in detail. From 326 observations of 84 pairs in 1880, the latitude was found to be + 40° 47′ 21″.59 ± 0″.82. From 591 observations of 104 pairs in 1881, it was found to be + 40° 47′ 21″.47, a difference of about 12 feet only. Sextant observations of latitude were also made. The errors of the several determinations were, 1″.1; 30″.5; 14″.8; 7″.4, 0″.9; 0″.5, respectively.

Longitude Determinations.—1st. By lunar culminations. The errors were found to be, (of one night's observations,) 7ˢ.01; 6ˢ.99; 3ˢ.14; 15ˢ.97; 3ˢ.74; 21ˢ.06. 14ˢ.29; 24ˢ.84; 20ˢ.58; 25ˢ.04; 4ˢ.06; 2ˢ.28; 1ˢ.81. The errors of each limb of the moon are separately shown.

2d. By Jupiter's satellites. Errors: 21ˢ.02; 29ˢ.48; 25ˢ.95.

3d. By lunar distances (sextant). Errors: 4ˢ.0; 25ˢ.0; 40ˢ.6; 13ˢ.7; 34ˢ.7; 6ˢ.4; 5ˢ.7.

The value of a revolution of the micrometer screw of the small (five inch) equatorial was twice determined, as follows:

$$\begin{aligned} R &= 19'' .362 \pm 0''.018 \text{ Polaris.} \\ &= 19\ \ .287 \pm 0\ \ .057\ \ \text{“} \end{aligned}$$

The displays of the aurora have been regularly noted since 1870, Feb. 1. The number for each year is as below:

1870, 99; '71, 104; '72, 94; '73, 92; '74, 35; '75, 27; '76, 17; '77, 13; '78, 4; '79, 16; '80, 22; '81, 44.

What has been given as an abstract of one year's work in one department only of this school of application for young engineer officers, is sufficient to show that we have at present no better school of practical astronomy in America. E. S. H.

The Lick trustees have ordered from the Messrs REPSOLD of Hamburg, a six-inch meridian circle of the design of that of the Strassburg Observatory. The objectives of the instrument and of the north and south collimators, are of six inches aperture, and will be made by ALVAN CLARK & SONS. The objective and eye end of the circle are interchangable. There are two divided circles, A and B. A is fixed on the axis and divided to 2′. B is moveable on the axis and is also divided to 2′. Every degree of each circle is numbered with an engraved figure. There are four microscopes to each circle, one revolution of their micrometers being 1′, and one part being 1″. The setting is done by a reflecting microscope with two eye pieces, one north, the other south. The axis of the circle is itself a telescope, and collimators east or west are used to rectify its position. The hanging level is so arranged that it can be applied while the instrument is pointed to the nadir. E. S. H.

THE MASS OF JUPITER.

Dr. Schur has made a new determination of the mass of *Jupiter* from heliometer measures of the satellites, an equal number of observations being made on each satellite. His results are:

From satellite I., $m = 1050.918 \pm 1.667$.
" " II., $m = 1046.026 \pm 1.425$.
" " III., $m = 1047.665 \pm 0.646$.
" " IV., $m = 1046.818 \pm 0.484$,

so that having regard to the weights, the mass of *Jupiter* is $\frac{1}{1047.232}$ ± 0.365. Bessel's published result by the same method was $\frac{1}{1047.879}$ but Dr. Schur has reduced Bessel's work anew, having regard to the corrections proposed by Auwers to the constants of the heliometer, (periodic error of screw, temperature coefficient, etc.,) and finds, in the mean for Bessel, 1048.629 ± 0.198, and combining by weights, the final mass of *Jupiter* from observations of the satellites by Bessel and Schur is

$$\frac{1}{1048.311 \pm 0.174}$$

Dr. Schur brings up some interesting questions in regard to the personal errors of observations of the satellites, for an account of which reference must be made to the original paper.

Various other series of measures of the satellites are discussed, but no changes are made in the concluded mass of *Jupiter*.

The mean motions and the periods of the satellites require only extremely small changes. E. S. H.

At the Cape of Good Hope much time was spent in 1881 on the determination of the longitude Aden-Cape, which is now completed. The cape catalogue for 1850, containing 4715 stars, will shortly be published.

Over 600 occultations, observed since 1834, have been reduced (by means of Newcomb's standard stars) and will be compared with Hansen's tables by Prof. Newcomb.

Dr. Huggins, has succeeded in photographing the *spectrum* of the nebula of Orion, (March 7, 1882), and from a note in *Nature* we learn that "in addition to known lines," a strong line in the ultra-violet is shown.

The same thing has also been done by Dr. Henry Draper, and from a private letter we learn that he has made four such photographs which show that two knots of nebulosity in the bright mass just preceding the trapezium, have a continuous spectrum, and that there are traces of the same in other parts of the nebula. E. S. H.

The double star observations of Baron Dembowski are to be published in the *Atti della R. Accademia dei N. Lincei.* They will fill three to four of the (quarto) volumes, or about 1,500 pages in all, and are to be edited by Professor Schiaparelli.

The Greenwich Observatory, always prompt in its publications, is this year even more prompt than usual. The volume for 1879 has been distributed; parts of the volume for 1880 have also been sent out, and the whole volume is nearly printed; and at the date of writing (February, 1882) the volume for 1881 is nearly ready for the printer.

At the Dublin Observatory, Professor Ball has nearly completed his investigation of the parallax of *Mu Cephei* and of *Struve* 2486. The catalogue of Red Stars is printing. The meridian circle is to be employed in determining the positions of about 1,000 stars between $-2°$ and $-23°$, for Dr. Schoenfeld.

Mr. Stone at the Radcliffe Observatory, is about to undertake some observations with the heliometer, which is being put into repair.

THE ZONE OBSERVATIONS OF THE GERMAN ASTRONOMICAL SOCIETY.

At the Strassburg meeting (1881, September) reports were made of the progress of the zone-observations, as usual. These are epitomized as below:

Kasan Observatory; zone $80° - 75°$. This zone is nearly finished.

Dorpat; zone $75° - 70°$. All the declinations are reduced to 1875.0 and the observations of R. A. partly reduced. The zone is almost completed.

Christiania; zone $70° - 65°$. This zone is, also, nearly completed.

Helsingfors—Gotha; zone $65° - 55°$. The observations are done and are now being printed.

Cambridge (U. S.); zone $55° - 50°$. The observations were completed in January, 1879, and required 633 nights for about 20,000 observations. The reductions will be finished in 1882.

Bonn; zone $50° - 40°$. The final catalogue is complete as far as 3^h.

Lund; zone $40° - 35°$. The observations will be finished in 1882.

Leyden; zone $35° - 30°$. The zones are printed, and the definitive catalogue is in preparation.

Cambridge (England); zone $30° - 25°$. 828 stars are yet to be observed.

Berlin; zone $25° - 20°$. This zone was observed by Dr. Becker and 80 per cent of the observations are made.

Berlin; zone $20° - 15°$. This zone is observed by Dr. Auwers and is nearly completed.

Leipzig; zone $15° - 5°$. The zone $15° - 10°$ has been completed

for some time. The zone $10° - 5°$, lately undertaken, will not be finished before 1885.

Albany; zone $5° - 1°$. Some 600 observations are yet to be made; 17,000 having been made.

Nikolaief; $+ 1° - 2°$

No reports were received.

Mr. Rutherfurd's Photography and Diffraction Grating.—In carrying forward his astronomical photography, Mr. Rutherfurd of New York first used an objective of eleven inches for several years; then he constructed another objective having a clear aperture of thirteen inches, for the same kind of work. The correction necessary to adapt the telescope to photographic work, was made by placing a meniscus flint lens in front of the visual objective, which shortened the focal length about one-seventh part. With this telescope a large number of star groups have been photographed extending over a period of ten years. All groups having a star of any perceptible proper motion have been taken with such star as the central one. Very many of these groups have been photographed at intervals of six months, for the purpose of seeing if any parallax could be detected. Many of the principal groups have been measured. A lady was employed for several years to do this kind of work, all of which requires proper reduction before it is ready for publication. When work of this kind embraces a considerable period of time, the relative movements of individual stars can be determined.

The great advantage of this method of mapping stars is at once apparent, as several photographs may be taken every good night, some having as many as 125 stars on a plate. These can be measured during the day by inexpensive assistance.

Mr. Rutherfurd has also given attention to spectum photography. In his first efforts, he secured photographs of the prismatic spectrum from near F to quite a distance into the invisible violet. Experience in this work plainly showed the need of a diffraction grating by which a normal spectrum could be obtained. Being unable to procure one, he resolved to make a machine for ruling the grating. After many trials he succeeded nobly, as many astronomers and physicists who have used the grating know and say.

These excellent diffraction gratings either on glass or speculum metal, are still manufactured by Mr. D. C. Chapman, who has been Mr. Rutherfurd's assistant for over ten years, and is now employed in the U. S Coast Survey office at Washington, D. C.

After Mr. Rutherfurd had made some grating, he began the measurement of the waves of light, and he very soon found that the fine definition of the spectrum lines enabled him to see quantities in the telescope of the spectrometer which he could not read on the divided circle (the usual kind with vernier). Larger and better circles

being provided he was able to read and measure to tenths of seconds of arc, which was a great step in advance for desired scientific results.

Another instrument of similar construction has been made foe the U. S. Coast Survey, and used by Professor C. S. Pierce, in thr measurement of waves of light, upon which the wave-length meter is to be founded. The first part of this work was done by the aid of Mr. Rutherfurd's experience and suggestions. It was accomplished by measuring, with the grating, the deviation of some line in the solar spectrum whose wave-length had been well determined by other persons.

Now assuming that the length of the wave given for this line is its true length, this number divided by the sine of the angle of deviation given by the grating, gives the value of the spacing of the ruling machine; then a grating was made two centimeters in width› with this grating the wave-length was measured, and found to agree with that given by the other persons, showing that the proper value had been assigned to the spacing according to the figures given. Then two glass decimeters were made and divided into two centimeter divisons, and each division on these decimeters was carefully compared with the two centimeter grating, several times over, thus the number of waves required to make up one of these decimeters becomes known. Now by comparing this decimeter with a standard decimeter or a standard meter, it will be seen if the *true* length of the wave had been given to that spectrum line; that is to say, if the new decimeter agrees with the standard, then it is evident that the value of the spacing of the grating with which Angstrom and others made their measures was right, and the true wave-length given, but it does not so appear. The new decimeter does not agree with the standard within the errors of observation. There is a mistake somewhere and it is believed by Professor Pierce that a small correction should be applied to the figures which have been given for the true wave-lengths. But it will require more work to determine the amount of correction necessary, and perhaps it will be deemed prudent to repeat the observations to be sure that it is correct.

PROFESSOR F. A. SMITH is procuring the instruments for the observatory at Beloit as rapidly as possible. The transit was made by Professor Lyman of Yale College, several years ago, and is a combination of the ordinary transit and the zenith telescope. It has been thoroughly repaired by Messrs. Fauth & Co. of Washington. The object-glass is 3¾ inches. Professor Smith has already received the sidereal chronometer, and a sextant made by Mr. Fauth. The objective for the equatorial is by Clark with clear aperture of 9½ inches and focal length of about twelve feet. The mounting will be done by Warner and Swasey of Cleveland, Ohio. A spectroscope and other apparatus are to be provided, which will make an excellent working outfit.

COMET-SEEKING.—That the search for comets may be systematic and as general as possible in this country, the following provisional arrangements have been suggested by the *Science Observer*, and almost universally commended by observers interested in the study of comets:

1. It is proposed to divide the sky into zones of declination, of which each observer has selected or been alotted one or more.

2. Each observer has expressed his intention to sweep carefully once at least during each month, the region selected by him, and some will sweep their zones several times each month. It is to be clearly understood that no observer is in any way confined to his zone, but is allowed to sweep anywhere, according to his judgment or circumstances.

3. As there are at present in the country three observers who are constantly engaged in comet hunting as their principal work, it is proposed to secure the complete covering of the sky once during each month by these observers, they having selected the following regions; Swift, + 90° to + 45°; Brooks, + 45° to + 15°, and Barnard, + 15° to − 45°.

4. To the other observers, who, from college duties or other regular work, can devote a varying part only of their time to comet seeking, smaller zones have been allotted, as follows: Tiffany, + 45° to + 30°; Wendell, + 30° to + 15°; Sharpless, + 15° to 0°; Larkin, 0° to − 15°, and Rebasz, − 15° to − 45°.

5. Other observers will keep a record of their observations, but cannot agree to sweep regularly enough to take charge of a zone.

6. This arrangement of zones secures the sweeping of the sky twice during each month, and their relation to each other provides, as well as possible at present, that the same storm, unless very extensive, will not be likely to interfere with both observers in the same region at the same time.

7. One of the important results of an organization will be the accumulation of data concerning comets and comet seeking. It has accordingly been agreed upon, by all observers, that records of their work will be kept. These will include a statement of the weather, the clearness of the sky, the time spent in search, the region covered, and any matters of general interest that may be of value. Blanks will be furnished to each observer, including a duplicate set for his own use, and these blanks, being returned on the first of each month, will be regularly published in each detail as may be necessary, in the *Science Observer*.

A NEW VARIABLE STAR.—While examining the heavens near the constellation *Cetus*, Dec. 18, 1881, Mr. Chandler of Harvard Observatory noticed a star nearly as bright as a fifth magnitude, which was not found in several of the star catalogues. In Dr. Gould's *Uranometria Argentina* it was given as 6.5 magnitude. By comparing it with neighboring stars, Mr. Chandler estimated its light

to be not fainter than 5.2 magnitude. Variability was suspected, and observations were continued from Dec. 18, to the 11th of February following, during which time the star diminished from 5.2 to 6.5 magnitude.

The position of the star for 1875.0 is:

$$\text{R. A.} = 0^h\ 15^m\ 28^s.$$

$$\text{Decl.} = -20^\circ\ 45'.1.$$

The star has a red tinge, and is noticeable in small telescopes.

SHORT-PERIOD COMETS.—So many typographical errors were made in the list of short-period comets given in our last issue, that the table is repeated. It is due to Professor Swift to say that none of those errors are chargeable to him.

Name.	Period	Name.	Period.
Encke	3.30 years.	D'Arrest	6.39 years.
Tempel (1873)	5.16 "	Biela	6.61 "
Swift	5.40 "	Faye	7.44 "
Winnecke	5.54 "	Denning	8.00 "
Brorson	5.58 "	Tuttle	13.16 "
Tempel (1867)	6.00 "	Halley	76.00 "

Gould = 1843 = 1880? 38 years.

LEHIGH UNIVERSITY, South Bethlehem, Pa., is provided with a Clark Equatorial telescope; aperture six inches. Professor Doolittle has it in charge.

EUGENE L. SCHAFER, Principal of Moravian Parochial school, Bethlehem, Pa., has an equatorial with aperture of 4½ inches, made by Mr. John Byrne of New York. It carries powers from 58 to 440, and does excellent work as Mr. Byrne's instruments are known to do generally.

A New Minor Planet of the 13th magnitude (No. 223) was discovered by Herr J. Palisa, March 9, at Vienna, Austria.

The firm of Messrs. Fauth & Co. of Washington, D. C., makers of all kinds of astronomical instruments, have already earned an enviable reputation in the astronomical world, for the ingenuity and skill constantly displayed in the designs and finish of their scientific instruments. While at their works in Washington recently, we were greatly interested and pleased to learn of many improvements in the make of various instruments. Cuts of some of these beautiful instruments will hereafter be given, that our readers may get a clearer idea of their improved mechanism and convenience. The merit of the work of this firm is well seen in the names of the following prominent astronomers who have purchased instruments during the last year.

PROFESSOR HARRINGTON, Ann Arbor—fixed astronomical transit and 6½ in. equatorial.

GENERAL ABBOTT, Willet's Point—5½ inch equatorial and equation machine.

XUM

Mt. Holyoke Seminary—18-inch meridian circle, astronomical clock and chronograph.

Professor Holden—Washburn Observatory—astronomical transit and chronograph.

Lick Observatory—Large astronomical transit and chronograph.

Professor Anthony, Cornell University—A twelve-inch spectrometer, clock and chronograph.

Professor Brackett, Princeton College—An eighteen-inch spectrometer.

Columbia College, New York—Transit and zenith instrument.

Besides these, a large number of instruments of various kinds have been supplied to the U. S. Coast Survey, and the Canadian Government, for the purposes of higher geodesy and engineering.

On the last page of the cover is a cut of P. H. Dudley's electrically controlled clock for railroad and city-time service. These clocks are in use, to some extent, by railroad companies in Wisconsin and Minnesota. They were introduced by Professor Holden of Washburn Observatory, and they are giving perfect satisfaction.

The basis of the system is, that a well conducted astronomical observatory ascertains and sends out the standard of time, and may control any number of clocks within telegraphic communication. Each controlled clock has its own complete train, weight and pendulum, and is not dependent upon any *expensive moter clock or attendant wires or pipes to keep it running.* Each clock has an electro-magnetic apparatus so arranged that upon receiving the signal from the observatory it instantly sets the hands either backward or forward, if in error, to the exact second of the signal. It is extremely simple in all its details. For railroad use the ordinary telegraph wires are used but a few moments daily, to send the signal to the clocks. Its utility is its greatest feature, for it places before all employees at stations the standard of time for comparison, thus permitting closer dispatch of trains with increased safety.

Messrs. Wm. Bond & Son, whose advertisement appears elsewhere, are the only manufacturers of chronometers in New England, and the firm is the oldest in that business in America, for after an existence in England for several generations, it was moved to this country by Wm. Bond in 1788, and permanently located in Boston, in 1793, where it is now represented by the fourth generation, their well known establishment in Congress street, having been one of the land marks of that nighborhood for over sixty years.

Although their principal attention is given to the manufacture and repairs of marine chronometers, they make a specialty of choice London watches for ladies and gentlemen, having imported the first chronometer watches ever introduced into this country, and being now the agents for three of the best manufacturers in London, they offer a large assortment of various styles and prices to suit all tastes.

ERRATA.—On page 1, fourth line from bottom read *is* for *are*.

On 16th page 11th line from bottom read *has* before *happened*, and on the 2d line from bottom read *not* before *exist*.